Sector Reforms and Institutional Corruption: Evidence from Electricity Industry in Sub-Saharan Africa

Mahmud I. Imam[*]
Tooraj Jamasb
Manuel Llorca
Durham University Business School, Durham University, UK

Abstract

In order to reduce the influence of corruption on electricity sector performance, most Sub-Saharan African countries have implemented electricity sector reforms. However, after nearly two and half decades of reforms, there is no evidence whether the reforms have mitigated corruption. Neither is there evidence of performance improvement of the reforms in terms of technical, economic or welfare impact. This paper aims to fill this gap. We use a dynamic panel estimator with a novel panel data of 47 Sub-Saharan African countries from 2002 to 2013. We analyse the impact of corruption and two key aspects of electricity reforms – creations of independent regulatory agencies and private sector participation – on three key performance indicators: technical efficiency, access to electricity and income. We find that corruption can significantly reduce technical efficiency of the sector and constrain the efforts to increase access to electricity and national income. The adverse effects are reduced where independent regulatory agencies are established and privatisation is implemented. These findings suggest that well-designed reforms not only boost the performance of the sector directly, but also indirectly reduce the negative effects of macro level institutional deficiencies such as corruption on micro and macro performance indicators.

Keywords: electricity sector reform; corruption; Sub-Saharan Africa; panel data; dynamic GMM.

JEL classification: Q48, D02, K23, D73.

[*] Corresponding author: Durham University Business School, Mill Hill Lane, Durham, DH1 3LB, United Kingdom. Tel. +44 (0) 74 69627145. Email: mahmud.i.imam@durham.ac.uk.

1. Introduction

Over the past two decades, a body of literature has emerged that establishes the various transmission channels through which corruption can constrain economic development. For example, corruption, defined as the "abuse of entrusted power for private gain",[1] is found to have corrosive effects on economic development through increasing transaction costs and uncertainty (Murphy et al., 1991), inefficient investments (Mauro, 1995; Shleifer and Vishny, 1993), reduced human capital development (Reinikka and Svensson, 2005), and misallocation of resources (Rose-Ackerman, 1999).

Recently, attention has shifted to another important but less explored micro-level channel, i.e., the operation and regulation of electricity sectors particularly in developing countries (Wren-Lewis, 2015; Estache et al., 2009; Dal Bó, 2006; Bergara et al., 1998). The preponderance of evidence from this strand of literature suggests that corruption can cripple economic development by inhibiting the performance of the electricity sector. For instance, corruption reduces labour productivity (Wren-Lewis, 2015; Dal Bó, 2006), increases transmission and distribution losses and constrains the efforts to increase access to electricity services (see Estache et al., 2009).

The impact of corruption on electricity sector performance is particularly relevant in Sub-Saharan Africa (SSA), where welfare improvements can be linked to widespread corruption (Gyimah-Brempong and de Camacho, 2006). Despite the difficulty of measuring corruption, the Corruption Perception Index (CPI) produced by Transparency International (TI, 2013) shows that eight of the twenty most corrupt countries in the world are in SSA and the only region with more than two countries in this group. Thus, in weak institutional settings, major

[1] See Kaufmann and Siegelbaum (1997) for discussions on this definition.

undertakings such as the construction of large hydroelectric dams, government intervention, monopolistic characteristics of the sector, absence of competition and substantial revenues from the sales of electricity make the sector vulnerable to corruption (Bosshard, 2005; World Bank, 2009; Reinikka and Svensson, 2005).

The above factors could be partly blamed for turning the electricity sectors in SSA countries into sources of corruption and cronyism (Patterson, 1999) and the concentration of electricity services to urban areas whilst rural areas remained unconnected or underserved (Byrne and Mun, 2003). This is referred to as 'electricity poverty' and is widespread in the region.[2] In order to improve efficiency and reduce corruption, many SSA countries have implemented Electricity Sector Reforms (ESRs) (Eberhard et al., 2016). Such reforms, also referred to as the 'standard electricity reform model' and often prescribed to developing countries by multilateral development organisations, were first implemented in OECD countries such as Chile, Norway and the UK in the 1980s and 1990s.

The experiences of these pioneer countries supported the notion that effective implementation of ESRs would not only enhance technical efficiency of the sector but would also translate the efficiency gains into social welfare and economic growth (Sen et al., 2016). Moreover, according to the World Bank (2000), as part of wider economic liberalisation, deregulation and demonopolisation policies, ESR policies were further underpinned by anticorruption agendas. Thus, reforms not only promised improved efficiency and access to reliable and affordable services, they also promised reduction in corruption in the sector (Estache et al., 2009) and the wider economy (World Bank, 2000).

[2] The majority of the estimated 500 million people who lack access to clean and affordable electricity in the region are poor and rely on traditional biomass – wood, agricultural residues and dung – for cooking and heating needs (IEA, 2014).

Despite the anticipated positive outcomes from implementation of the reforms, there are widespread perceptions that reforms have hurt the poor through increased tariffs, stronger enforcement of bills collection (Scott and Seth, 2013) and unemployment, while benefitting the powerful and wealthy notably through corruption (Auriol and Blanc, 2009). As a result, the reforms often lacked social legitimacy, and this usually manifests through increases in electricity theft and vandalism (Williams and Ghanadan, 2006). Moreover, as Estache et al. (2009) have noted, large numbers of people believe that corruption still remains a problem in the sector. However, despite the anecdotes that connect corruption to sector performance after the reform efforts, there is a lack of empirical evidence on whether the electricity sector reforms in SSA region have mitigated or exacerbated the effect of corruption in the electricity sector.

Previous empirical studies have shown the relevance of corruption as a driver of ESR in developing countries, but they either focus on labour efficiency in electricity distribution utilities (e.g., Wren-Lewis, 2015; Dal Bó and Rossi, 2007) or on different sectors (e.g., Estache et al., 2009). Moreover, the former two studies focused on Latin American countries while the latter study includes countries from different developing regions. Therefore, to our knowledge, this is the first empirical study to assess the electricity reforms in SSA countries and among the few studies that examine the interactions between country level institutions and micro-level electricity reform steps (e.g., Wren-Lewis, 2015; Estache et al., 2009). Most studies of this strand of literature tend to focus on specific aspects of the textbook reform model or on specific countries without explicitly accounting for the role of institutions apart from those earlier mentioned.

Our paper addresses the gap in the literature and contributes to better understanding of the institutional aspect of electricity sector reforms (e.g., Dorman, 2014; Chang and Berdiev, 2011; Nepal and Jamasb, 2012a; Cubbin and Stern, 2006; Erdogdu, 2013) and the political economy literature of regulatory agencies (e.g., Pitlik, 2007; Potrafle, 2010; Scott and Seth, 2013). This study indirectly contributes to the literature on obsolescing bargaining (Vernon, 1971) since political corruption entails government commitment to honour the terms of electricity reforms and particularly the privatisation of state assets, could be doubtful. Thus, the findings provide further insights into why investments in the SSA electricity markets tend to be more concentrated in the generation segment than in the distribution utilities since the former is more susceptible to corruption.

The remainder of this paper is as follows. Section 2 reviews the nearly three decades of ESR in SSA countries and discusses how each of the key steps of the reform model may mitigate the adverse effects of corruption on the performance of the electricity reforms. Section 3 presents three research hypotheses related to key performance aspects of reforms to be tested. Section 4 presents the empirical methodology and the data used in the study. Section 5 presents and discusses the results. Section 6 concludes the paper.

2. Electricity Sector Reforms in Sub-Saharan Africa

Historically, the generation, supply and marketing of electricity in most SSA countries, as in many other regions of the world, were dominated by vertically integrated state-owned utilities (Clark et al., 2005). These arrangements were partly regarded as primary functions of the state, such as, the high fixed costs of large plants, the desire of governments to enhance welfare, national security concerns, social equity objectives (World Bank, 1993) and ideological reasons (Erdogdu, 2013). The state-ownership was reinforced by the idea that permitting more than one firm would increase costs while this resulted in higher investments by public utilities relative to private utilities (USAID, 2005). The 1980s and 1990s saw SSA countries unable to sustain investments in the sector. Decades of government investments had not produced the anticipated results as services and subsidies remained concentrated in urban areas, nor were there improvements in quality and reliability of service.

The first electricity reform took place in Chile in 1983, and then in OECD countries such as Norway and United Kingdom. From these experiences emerged the theory and practice of the ‘standard textbook reform model’. It was believed that reforms would reduce the dominance of the state through creation of Independent Regulatory Agencies (IRAs) and private sector participation (Jamasb et al., 2016). The expected outcomes were the enhancement of economic and technical efficiency of utilities and the transfer of efficiency gains to consumers in the form of improved access to affordable and reliable electricity (Nepal and Jamasb, 2012b; Estache et al., 2009).

In SSA, macroeconomic conditions such as the deteriorating international business climate, fiscal constraints faced by governments, structural adjustment programmes (Jamasb, 2006) compelled the countries to undertake structural and institutional reforms of their sectors. Many of the arguments that supported state ownership of utilities disappeared by the 1980s as the economies of scale of vertically integrated utilities had been exhausted (Joskow, 2006; Gilbert et al., 1996), therefore state-ownership came to be seen as a hindrance to adoption of new technologies by the private sector (Downing et al., 2006). The reforms in SSA were triggered by investment shortfalls and concerns that monopolisation of the sector by state-owned utilities were wasteful and inefficient (Victor, 2005).

The standard reform model calls for the unbundling of state-owned electricity utilities vertically (generation, transmission, distribution and retailing) and horizontally (generation and retailing). The unbundled parts amenable to competition would then be sold to the private sector and an independent sector regulator would supervise and regulate the natural monopoly parts of the sector (Victor and Heller, 2007). The electricity sector specific and external factors that triggered ESR varied in developed and developing countries (Jamasb et al., 2016). In addition, the extent and outcome of reforms have differed in these countries (Nepal, 2013). The reforms in developed countries were undertaken in the context of excess capacity and stable institutions aimed at improving economic and financial performance of technically reliable systems, encourage interregional trade, transfer investment risks to the private sector, offer consumer choice, and reduce overinvestment (Jamasb et al., 2014; Erdogdu, 2013). Conversely, ESR in the developing countries were implemented within a context of poor technical and financial performances of state-owned utilities, weak institutional setting, inability of utilities and governments to mobilise sufficient investments to provide access, low tariffs and poor service quality (Jamasb et al., 2005).

However, the suitability of the standard reform model for developing countries has been questioned as it has usually resulted in higher prices, loss of employment, unreliable service, and concentration of service to profitable areas since private firms did not have incentives to extend the service to poor people (Transnational Institute, 2002; Victor, 2005). Thus, in the unprofitable segments there has been an absence of service provision (Auriol and Picard, 2006). The poor access rates in SSA relative to other developing regions may be partly attributed to this lack of incentives. For example, although between 2000 and 2014, there was some progress in increasing access to electricity in all developing regions of the world; access deficit is overwhelmingly concentrated in SSA region, as progress has fallen consistently short of population growth. The poor outcomes have led the reform critics to argue that the state should take the responsibility for such investments (Victor, 2005).

Moreover, the experiences of ESR around the world have shown the difficulty of creating efficient electricity sectors underpinned by genuine competitive markets that show significant potentials to benefit consumers through reliable service, low tariffs, and choice of alternative sources (IEA, 2014). As a result, the reform experience in SSA has lagged behind the anticipated outcomes of the standard reform model and has led to extensive political backlash against the reforms. Higher electricity prices have been an obvious source of political resistance in many countries, especially for groups that have become accustomed to paying near nothing for electricity services (Victor, 2005) and this resistance was further reinforced by the awareness that elections can be won or lost because of electricity prices (UNDP and World Bank, 2005).

However, the difficulties of ESR in developing economies have not deterred SSA countries from implementing some aspects of the textbook reform model. Twenty-four of the countries in the region have enacted ESR law, three-quarter have attracted private participation, nearly all have corporatized their utilities, two-thirds have set-up regulatory bodies, and more than a third have Independent Power Producers (IPPs) in place (Eberhard et al., 2016). Table 1 summarises the reform efforts in the SSA countries studied here.

No ESR Initiated	Vertically integrated w. priv.*	Vertically integrated w. IRA only	Vertically integrated w. IRA and priv.	Unbundled w. IRA and priv.	Unbundled w. IRA only
Benin Burundi Central African Rep. Djibouti Equatorial Guinea Eritrea Seychelles Congo Dem. Rep. Guinea	Botswana Chad Madagascar Mauritius Liberia Guinea Bissau Comoros Congo, Rep.	Mauritania Niger Swaziland	Angola Burkina Faso Cape Verde Cameroon Côte d'Ivoire Ethiopia Gabon Gambia Malawi Mali Mozambique Namibia Lesotho Rwanda São Tomé & Príncipe Senegal South Africa Tanzania Togo Zambia	Ghana Kenya** Nigeria Uganda Zimbabwe**	Sudan

* All forms of private participation excluding management contracts, lease contracts and concession.
** Kenya and Zimbabwe have only undertaken partial unbundling.
*** Somalia and South Sudan are not included in our analysis. The former due to the lack of data. The latter country gained independence from (North) Sudan in 2011 and our data covers until 2013.

Table 1. Implementations of Electricity Sector Reforms in SSA countries
Sources: Eberhard et al. (2016) and World Bank Infrastructure Database (2017)

3. Literature on Corruption and Sector Reform

Corruption and Corporatization/Commercialization

Although independent and incorporated under the same laws governing private corporations, the state retains ownership of corporatized utilities and in some cases runs them through appointed independent board of directors. Whether managed by an appointed board of directors or private contractors, corporatizations of utilities were mainly aimed at reducing the inefficiencies induced by government interference in their operations, facilitate the entry of private capital and move utilities toward cost-recovery in pricing through improved metering, billing and collection (Eberhard and Gratwick, 2011).

Corporatized utilities have achieved modest performance improvements especially those operated by management contractors.[3] Positive outcomes such as improvements in bill collections and reductions in system losses in almost all SSA with management contractors, made international aid agencies involved in most management contracts, to regard them as a first step towards comprehensive reforms. However, contracting out to private sector has been difficult and contentious in some countries. For example, most governments were unwilling to honour their financial obligations needed to expand capacities, reject tariff hikes (e.g., in Senegal), unwilling to compel government agencies to pay their bills, forbidding utilities from reducing the workforce or disconnecting delinquent consumers (Nellis, 2005). Stakeholders removed from management positions or employees laid off criticised such contracts especially where large fees were paid to management contractors (Eberhard and Gratwick, 2011). The large payouts were argued not to be commensurate with the modest improvements in the finances of utilities. This helped galvanise a political backlash against such contracts in the region. Moreover, many regulators failed to capture the efficiency gains and competition from management contractors (Nellis, 2005). As a result, management contracts were viewed as unsustainable. Of 16 such contracts in SSA, 4 were cancelled before their expiration dates, 12 were allowed to expire after their initial terms, and only in Liberia and Lesotho there are active contracts. Eberhard and Gratwick (2011). Meanwhile, Gabon and Mali have adopted further reforms.

The eventual disengagement of management contractors from many SSA countries shows that state-owned utilities still dominate the sector. Some governments force utilities to charge electricity prices below the costs of generation and supply, dictate the choice of plants locations or mandate utilities to purchase their energy from state-owned companies (Nellis, 2005) even

[3] See Appendix A for types, project names and status of management contracts in the countries of our sample.

while lower cost alternatives exist. Thus, it became increasingly difficult to insulate corporatized utilities from corruption usually associated with state ownership of utilities, which has been a key motivator of reforms in the region.

Corruption, Unbundling and Competition

In order to target the sources of inefficiency such as corruption, reformers have advocated for the introduction of competitive electricity markets after the sector is unbundled vertically and horizontally. Thus, irrespective of ownership status, reformers anticipate that competition between the unbundled segments and generating plants offers a reliable mechanism to reduce energy losses and increase capacity utilisation. The gains are expected to increase access rates, while reducing the cost of service to existing consumers (Zhang et al., 2008). More importantly, unbundling and the subsequent competition entails consumers will have more freedom of choice. This also means that consumers can escape from corruption hitherto associated with government-owned utilities. In SSA, only Nigeria has taken steps towards wholesale competition after unbundling and privatising the generation and distribution segments (Gratwick et al., 2006).[4] Although, the lack of competition in electricity markets of SSA countries can partly be linked to the difficulties of reforming small systems, the absence of private participation in countries such as Sudan,[5] indicates that governance issues are still at the core of the electricity reform efforts in many countries.

Despite the governance enhancing virtues of competition, experience reveals the difficulties of creating genuine competitive electricity markets even in developed countries which are usually associated with strong institutions. In SSA, the emergence of hybrid electricity markets and the lack of robust anti-competitive laws may explain the absence of competitive electricity markets

[4] Nigeria established a Transitional Electricity Market (TEM) on February 1, 2015.
[5] Sudan has successfully unbundled its power sector vertically and horizontally, and has established an IRA.

apart from the TEM in Nigeria and the predominance of private sector largely in the form of IPPs. This is because competitive retail or wholesale electricity markets require sophisticated institutional and financial infrastructures (Eberhard et al., 2016). In order to mitigate investment risk in weak institutional environments, private participants such as IPPs often enter into power purchase agreements with the incumbent off-takers by requiring government guarantees, and inclusion of international arbitration clauses.

Corruption and Private Sector Participation

Privatisation can improve the performance of the sector through changing the incentive structure. The owners of privatised utilities are the residual claimants of revenue generated by the utility, incentivising them to close inefficiencies including those related to corruption (Olson, 2000). In order to attract investments many reformers advocated privatisation of state-owned utilities to complement private sector participation. The withdrawal of the state from the sector would not only attract private investments and reduce the burden of subsidies on the government from financial overruns of state-owned utilities. Therefore, privatisation can reduce political interference or bureaucratic rigidities in the operations and management of utilities since control rights over these factors would no longer be under the direct control of politicians or civil servants. Despite the increase in private participation after the financial crisis of 2008 in SSA electricity sectors (Figure 1), there remains a funding gap for connecting the estimated 500 million people without access to electricity services in SSA (IEA, 2014). ADB (2010) notes that social welfare improvements and productivity in the region, continues to be constrained by the inadequate generation capacity, large technical and commercial losses, limited electrification, unreliable services, and high tariffs.

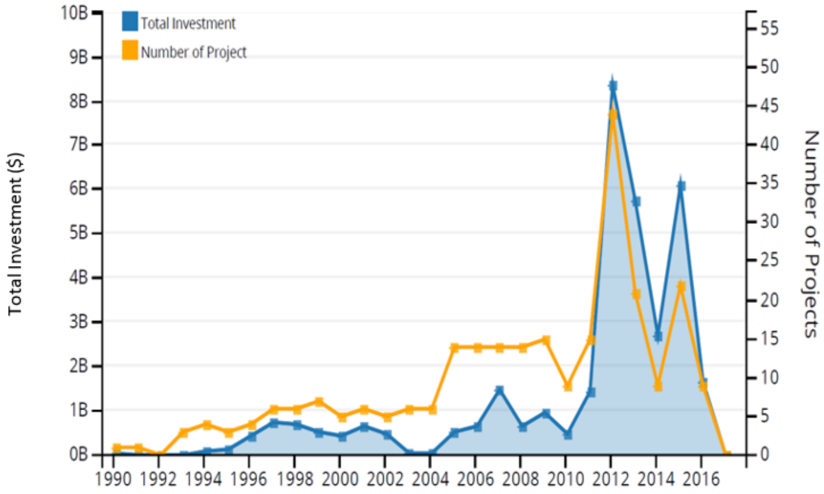

Figure 1: IPP Investments in SSA Countries, 1990-2016
Source: World Bank PPI Database

Corruption and Independent Regulatory Agencies

Previous studies have linked large energy shortages and investment gaps to historical, financial, social, technical, and economic factors (e.g., Jamasb et al., 2016; Dornan, 2014; Eberhard and Gratwick, 2011). Recently other studies have linked the poor outcomes to the failure of IRAs to improve the institutional conditions of the sector as private investments largely depend on their credibility and independence when investing in countries with weak institutions. Moreover, the emergence of hybrid electricity markets which does not entail total withdrawal of the state from the sector (Eberhard et al., 2016),[6] have made the IRAs to struggle to balance the interests of private utilities and the dominant state utilities. Thus, in the context of weak institutional environments of SSA, political expediency tied to the state-owned utilities tends to undermine the independence of the IRAs (Eberhard, 2007). As a result, the regulatory frameworks in these countries are often viewed as compromised. This leads many consumers to assume that the utilities are in collusion with the IRAs and make excessive profits since the

[6] This is one of the key factors often suggested for the vulnerability of the electricity sector to corruption.

regulatory framework has become prone to political capture or a tool for corrupt government officials (Stiglitz, 1998).

According to Eberhard et al. (2016) as of 2014, only 26 of the SSA countries have set up IRAs, while in the remaining countries, energy ministries or departments have the regulatory responsibilities and social and economic objectives. Thus, in the latter group of countries, governments have full regulatory discretion in determining and enforcing tariffs and service standards. Some argue that self-regulation allows corruption to be pervasive in the operations of utilities as most positions in IRAs are usually staffed with friends, family, or political and financial allies of politicians (Estache and Wren-Lewis, 2010). In weak institutional settings, the sector could be influenced by the private agendas of regulators, government, or corruption. Despite the links between weak institutions and performance of utilities, the issue of how corruption and weak governance influence the electricity sector performance post reforms has been neglected in the reform literature and the policies of SSA governments. In order to fill this gap, we analyse whether the implementations of ESR have offset or exacerbated the negative influence of corruption on performance.

3.5. Hypotheses

As noted earlier, the main objective of ESR in SSA countries was to improve technical efficiency and translating this into increase electricity access and keep up with economic growth. In order to develop a set of hypotheses to test whether these objectives have been achieved, we rely on the literature on corruption in regulated sectors about how a well-designed regulatory framework may insulate firms from corruption (Levy and Spiller, 1994; Laffont and Tirole, 1986; Estache and Wren-Lewis, 2009). We are further guided by the development literature that states economic performance could be affected indirectly through the impact of corruption on private investment (Wei, 2000). We draw on this literature to identify three indicators of electricity sector performance to assess the corruption reducing potential of ESRs. The variables are placed into three categories each reflecting different dimensions of performance – i.e., technical efficiency, electricity access and economic performance. The first hypothesis focuses on the technical efficiency of electricity sector proxy by Transmission and Distribution (T&D) losses per capita and is as follows:

- *H1: Electricity sector reforms in SSA countries, by offsetting or overcoming the adverse effects of corruption, have improved technical efficiency.*

T&D energy losses are a proxy for technical efficiency because high losses indicate that firms are not only undertaking the needed investments to upgrade and maintain supply networks. It also indicates that firms have operational challenges. Also, vandalism, illegal connections and bribes to workers to avoid electricity bills contribute to high losses and prevents the utilities from undertaking further investments. These factors adversely affect the overall sustainability and productivity of the sector. Therefore, we expect the reforms to enhance investor confidence to undertake investments, improve operations and close sources of inefficiencies leading to efficiency gains. We extend the assessment of impacts of ESR and corruption beyond the sector since one motivation of reforms in SSA was to expand the service to the unelectrified majority. Therefore, our second hypothesis traces the impacts of reforms to their effect on access to electricity. Previous research has suggested how corruption and clientelistic practices (e.g., Min, 2010) undermine government efforts to extend the service to the poor. Therefore, we expect the loosening of the ties between the government and utilities, through the creations of IRAs and privatisation, to reduce corruption normally related to government operations and regulation of utilities. Moreover, we expect technical efficiency gains from ESR to translate into expansion of electricity service to those who lack access. Thus, our second hypothesis is as follows:

- *H2: Implementation of ESR by reducing the negative association between corruption and technical efficiency has increased electricity access in SSA countries.*

According to IEA (2014), reforms will boost the economic performance of SSA region by 30% in 2040, not only through private investments but also through governance improvement inside and outside the energy sector. Moreover, World Bank (2000) notes that ESR as part of wider economic liberalisation policies has the anticorruption potential to reduce the negative association between corruption and economic performance. Therefore, due to the positive association between the economy and electricity use on the one hand, and the negative association between corruption and economic performance, we expect the reforms to increase income levels. We therefore postulate that:

- *H3: Implementations ESR policies in SSA countries have enhanced economic performance of SSA countries by reducing negative association between corruption and economic growth.*

4. Methodology and Data

Electricity Sector Performance Estimation

The setup and analysis of the performance equation is influenced by the awareness that ESR in developing countries, as in other sectoral reforms, is not an isolated undertaking but is closely interlinked with the legal and institutional environments of reforming countries. Therefore, in its simplest form, we postulate that electricity sector performance (*Y*) depends not only on the vector of reform policies (*REF*) implemented by SSA countries but also on corruption (*cor*) which measures the institutional quality of the countries, and a set of control variables (*X*). Thus, our performance output equation can be expressed as:

$$Y_{it} = \alpha_i + \sum_{p=1}^{2} \beta_{1p} REF_{pit} + \beta_2 cor_{it} + \sum_{p=1}^{2} \beta_{3p} \left(REF_{pit} \cdot cor_{it} \right) +$$

$$\beta_4 ira_{it} priv_{it} + \sum_{q=1}^{Q} \beta_{5q} X_{it} + \beta_6 time + \varepsilon_{it} \qquad (1)$$

where *i* and *t* index a country and year, *Y* is the performance output reflecting either of the three performance indicators: technical efficiency (T&D energy losses; *losses*), electricity access (per capita electricity consumption; *access*), and economic performance (GDP per capita; *gdpper*). βs are the parameters to be estimated, the term *time* represents a linear time-trend, which takes into account technological progress. α_i are country-specific effects, included to control for time-invariant unobservables and $\varepsilon_{it} \sim N(0, \sigma^2)$, is the stochastic error term. The vector of reform policies (*REF*) consists of two dummies that reflect the existence of an independent regulatory agency (*ira*) and privatisation (*priv*), a proxy for all forms of private sector participation in electricity sectors. These two reform policies entail whether country *i* at time *t* has succeeded in establishing an independent regulatory agency and opened its doors for private participation. The vector of Q control variables (*X*) depends on which of the three performance indicators is used. It captures the demand side of the market and consists of GDP per capita (*gdpper*), total gross electricity generation (*genper*), structure (*struc*) and size (*urban*) of the electricity sector.

In order to capture the corruption reducing effects of ESR on performance, we follow Estache et al. (2009) and Wren-Lewis (2015) and use interaction terms between corruption and the two reform policies (*iraXcor* and *privXcor*). The coefficients of these two interaction terms measure the corruption reducing potential of reforms. We also include an interaction term between the two the reform policies (*iraXpriv*) to assess whether IRAs have constrained or improved the performance of privatised utilities or if private utilities have constraint or reinforced regulatory activity. This is important because, private investors in electricity sectors of developing countries mostly require credible and transparent IRAs to safeguard their investments from expropriation by the state.

Similarly, as noted in the literature on regulatory capture, there is a tendency for regulatory capture in regulated electricity markets due to economic incentives that may push regulators to cater for the interest of the regulated (e.g., Olson, 1965; Dal Bó and Di Tella, 2003; Leaver, 2009). These incentives may arise due to reliance of the regulators on the regulated entity for information they need to do their duties and the desire to hold future well-paid jobs with the regulated since human capital in the sector tends to be industry-specific. Hence, this is our motivation for the inclusion of the third interaction term.

Estimation method

In panel data regressions, the choice of an estimator mostly lies between the Random Effects (RE) or Fixed Effects (FE) estimators to deal with the bias of unobserved heterogeneity. However, both estimators address the bias at the expense of a strong exogeneity assumption. For instance, Equation (1) includes not only country-specific effects that can be correlated with other regressors, but also other theoretically established endogenous regressors (e.g., per capita GDP), thus the orthogonality condition is not likely to be met for a RE or FE estimator to produce consistent estimates. Jamasb et al. (2005) note that most ESR researchers tend to ignore (implicitly or explicitly) another sources of endogeneity which arises from the possibility of current values of ESR variables and past performance being a function of past condition or performance. The RE and FE estimators do not produce consistent coefficient estimates in the presence of endogenous regressors and dynamics, and thus it is not possible to make inferences based on their estimates.

In order to overcome the methodological concerns, we transform (1) into a dynamic panel specification where lagged values of the three indicators of performance, i.e., the alternative dependent variables (technical efficiency, electricity access and per capita GDP) are included as additional regressors. The dynamic performance equation can be expressed as in (2):

$$Y_{it} = \varphi Y_{it-1} + \alpha_i + \sum_{p=1}^{2} \beta_{1p} REF_{pit} + \beta_2 cor_{it} + \sum_{p=1}^{2} \beta_{3p} \left(REF_{pit} \cdot cor_{it} \right) +$$

$$\beta_4 ira_{it} priv_{it} + \sum_{q=1}^{Q} \beta_{5q} X_{it} + \beta_6 time + \varepsilon_{it} \tag{2}$$

where Y_{it-1} denotes the lagged value of performance, whilst φ is the parameter associated with that variable. Other variables and coefficients are defined as before. As noted, neither the pooled OLS, FE nor RE estimates of φ are consistent in dynamic models when the time span is small (Nickell, 1981). We could consider using the dynamic panel General Method of Moments (GMM) estimator proposed by Arellano and Bond (1991). This estimator has the potential to produce consistent estimates in the presence of endogeneity of regressors, unobserved country fixed effects and dynamics. This estimator first eliminates the country-specific effects α_i by differencing the model and instrumenting the lagged dependent variable (Y_{it-1}) with lagged levels of this variable (Arellano and Bond, 1991). However, differencing the data removes all time-invariant variables of interest during the estimation. Moreover, the Difference GMM (Diff-GMM) is noted to perform poorly in the presence of persistent processes since the lagged levels may convey little information on future changes, thus implying the problem of weak instruments and biased estimates (Roodman, 2008).

Arellano and Bover (1995) and Blundell and Bond (1998) developed a System GMM (Sys-GMM) estimator to improve the efficiency of the Diff-GMM estimator. The Sys-GMM estimator solves the endogeneity problem by treating the model as a system of equations in first difference and in levels. The endogenous regressors in the first difference equation are instrumented with lags of their levels, whilst the endogenous regressors in the level equation are instrumented with the lags of their first differences. The consistency of the Sys-GMM estimator depends on the assumption of no serial autocorrelation in the errors and existence of an array of exogenous regressors. The estimator relies on internal instruments contained within the panel itself and therefore eliminates the need for external instruments and it also avoids full specification of the serial correlation and heteroscedasticity properties of the stochastic error term, or any other distributional assumption.

Despite its advantages, the Sys-GMM estimator has limitations especially as it relies on using the lags of both the dependent and independent variables for identification. This would potentially give rise to a problem of weak instruments, which is usually magnified as the number of instrumental variables increases. Although, increasing the instruments' lag length could make them more exogenous, it may also make them weaker. Furthermore, when using panel data estimators such as the Sys-GMM, the bias resulting from errors in regressors may also be magnified (Griliches and Hausman, 1986). In order to reduce the influence of these and other limitations of the estimator on our results, we avoid the instruments counts exceeding the number of countries in the sample or overfitting of the instrumented regressors. Thus, we collapse the instrument set as recommended by Roodman (2009) and report the instrument count for each of the estimations.

Obtaining consistent, efficient and unbiased results using the Sys-GMM estimator is contingent on two specification tests; Hansen test for over-identification restrictions and the Arellano and Bond (1991) test for serial correlation (AR) of the disturbances up to the second order. The Hansen test of over-identification restrictions is a joint test of model specification and appropriateness of the instrument vector. Failure to reject the null hypothesis of the test would indicate that the instruments used in estimation are valid and the model has been well specified. The appropriate check of the Arellano and Bond (1991) test for serial correlation (AR) relates only to the absence of second-order serial correlation (AR2) since the first differencing induces first serial correlation in the transformed errors.

Data

Our econometric analysis is based on annual country-specific observations from 47 SSA countries from 2002 to 2013. The selection of countries and period are determined by data availability. Since the main focus of the paper is on the influence of IRAs and privatisation on corruption, the limited reforms implemented so far in the region would not permit us to assess the impacts of ESR and corruption before 2002. Similarly, the final year 2013, represents the last year for which data are available on electricity consumption per capita and T&D losses at the time we conducted the analyses. Also, we do not have complete data for all the years and countries. Therefore, as we analyse different performance indicators the sample size also changes.[7] Table 1 shows all the countries included in our analysis.

As noted, the three performance indicators (technical, welfare and economic impacts) are measured by T&D losses (*losses*) as a percentage of total electricity production, per capita electricity consumption (*access*)[8] and GDP per capita (*gdpper*). Data on *access* is obtained from the U.S. Energy Information Administration (EIA) database, while data on *losses* and *gdpper* are from the World Bank Development Indicator Database. Data on corruption is from Kaufmann et al. (2010) included in World Bank's Governance Indicator Database, which includes annual country-level data. The corruption index, which measures corruption in both

[7] The different sample sizes are reported at the bottom of the estimation results tables in the next section.
[8] See Appendix B for a discussion of this measure as a proxy for access to relative to alternative indicators. The variable has been averaged by total population data from World Bank Development Indicators database.

public and private sectors, ranges from -2.5 (highly corrupt) to 2.5 (highly clean). Data on *ira* was obtained from Eberhard et al. (2016) and updated with data from Burundi, Cape Verde, Madagascar, Seychelles and São Tomé and Príncipe electricity regulatory agencies' websites.[9] Data on *priv* was obtained from the World Bank Infrastructure Database. Table 2 summarises summary statistics of the variables used.

Variables Names	Labels	Unit	Obs.	Mean	Std. Dev.	Min.	Max.
Electricity Gen., Per Capita	*genper*	kWh per capita	562	435	880	8	5,306
Regulator	*ira*	Dummy	564	0.49	0.50	0	1
Privatisation	*priv*	Dummy	564	0.58	0.49	0	1
Corruption	*cor*	Index	564	-0.60	0.58	-1.71	1.25
Urbanisation	*urban*	%	562	38.49	16.27	8.68	86.66
Elect. Consumption, Per Capita	*access*	kWh per capita	562	628	1,467	7	10,566
Household Elect. Consumption	*hols*	Million kWh	528	1,755	5,806	4	41,173
Export	*export*	%	528	35.11	22.38	4.43	122.26*
Industrialization	*ind*	%	522	26.24	14.30	3.33	84.28
T&D Losses	*losses*	%	271	20.52	14.36	2.93	86.75
GDP, Per Capita	*gdpper*	2010 US$	562	1,792	2,404	194	12,634
Population Density	*popden*	Inhab./km^2	562	86.63	112.45	2.38	620
Structure	*struc*	Dummy	564	0.09	0.29	0	1

Note: *genper, access, hols, gdpper* and *popden* were log-transformed prior to estimation
* Equatorial Guinea is a notable exception with exports being larger than GDP

Table 2: Summary Statistics

The data for the control variables *urban* and *genper* were obtained from the World Bank Development Indicators and the U.S. EIA respectively. Data for *struc* was obtained from World

[9] See Burundi's Drinking Water and Electricity Sector Control and Regulation Agency (ACR): https://www.ppbdi.com/index.php/extras/economie-sciences-education-formation/3397-ministere-de-l-energie-et-des-mines-regulation-du-secteur-de-l-eau-potable-et-de-l-electricite; Cape Verde Agência de Regulação Económica: http://www.are.cv/index.php; Madagascar office de régulation de l'electricité: http://www.ore.mg/; The Seychelles Energy Commission (SEC): http://www.sec.sc/; and São Tomé and Príncipe Autoridade Geral de Regulação: http://www.ager-stp.org/index.php/pt/.

Bank Development Indicators Database and updated with data from African Development Bank Energy Utilities Database, included in the Africa Infrastructure Knowledge Program. Using these data, we follow Jamasb et al. (2004) to create an index of binary numbers 1 and 0 to indicate whether a country has unbundled its electricity sector. *urban* is a proxy for the size of electricity markets and is measured as the percentage of total population that resides in urban areas. In addition, the data on total household electricity consumption (*hols*) was obtained from the United Nation's Energy Statistics Database.

Finally, in order to test the robustness of our results we included three additional explanatory variables - share of industrial output (*ind*), trade openness (*export*), and population density (*popden*) - in the performance equations in alternative estimations. [10] The data for these variables were obtained from World Bank Development Indicators Database.

5. Results

This section presents the results of the three performance dimensions of electricity (technical, welfare and economic impacts) using a dynamic panel Sys-GMM estimator. We first discuss the estimates of the T&D energy losses equation, then electricity consumption per capita, and finally the estimates of the GDP per capita equation. The results in Tables 3-5 indicate that they fit the data well. The AR(1) and AR(2) test statistics indicate that there is first order serial correlation, but not at the second order, which suggests the inconsistency of OLS and appropriateness of a GMM estimator in our context (Arellano and Bond, 1991). In addition, the Hansen test of model specification and over-identifying restrictions indicates that all three models are correctly specified with appropriate instruments. Our estimation strategy differs

[10] The results of the robustness checks do not show major differences with respect to those finally presented in this paper. These alternative models are presented and briefly discussed in Appendix C.

from earlier studies that use static models to analyse the impacts of ESR on performance (Zhang et al., 2008; Estache et al., 2009; Wren-Lewis, 2015).

Technical Impact – T&D Losses

The immediate impacts of ESR are the technical improvements on the sector. The estimates of the Sys-GMM estimation in Table 3 shows that, the coefficient of *cor* is negative and highly significant, suggesting that an increase in the corruption index (i.e., the country is cleaner in terms of corruption) is associated with reduction in energy losses.[11] Thus, corruption can be considered here as a major source of inefficiency in SSA countries. Therefore, adopting measures to reduce corruption can have positive impact on technical efficiency. This result is similar to those obtained by other studies that have found a positive relationship between corruption and inefficiency in the sector (Dal Bó, 2006; Estache and Trujillo, 2009; Dal Bó and Rossi, 2007; and Wren-Lewis, 2015).

The coefficient of *ira* is significant and positive suggesting that, the creation of IRAs has led to a statistical increase in energy losses. A similar result was obtained by Nagayama (2010) who finds the establishments of IRA led to an increase in T&D losses in Latin American and some former Soviet Union countries. Similarly, Smith (2004) and Zhang et al. (2008) find reform policies such as the creations of IRAs are associated with deterioration in energy losses. The coefficient of *priv* is not significant indicating that, private sector participation has no impact on the technical efficiency of the sectors during the period of our study. This result contrasts with Clark et al. (2005) who find the introduction of private participation in countries such as Namibia, Nigeria, Uganda and Mali is associated with efficiency improvements. This

[11] It should be noted that the dependent variable of this model, i.e., T&D losses, is expressed in the form of percentage and has not been log-transformed. This explains the large magnitude of the estimated coefficients, which must be interpreted as the effects, measured as changes in percentage points of the dependent variable, due to increases in the explanatory variables.

also contradicts earlier studies that find private participation in the electricity sector is associated with technical efficiency improvements (e.g., Andres et al., 2008; Nagayama, 2007; Balza et al., 2013).

Technical Impact (*losses*)		
Variable	**Est.**	**t-stat.**
losses(t-1)	0.429***	4.42
cor	-16.431**	-2.19
ira	8.626**	2.24
priv	12.703	1.59
struc	1.081	0.67
iraXcor	9.749***	4.94
privXcor	9.342	1.18
iraXpriv	-2.105	-0.58
ln *hols*	-3.677***	-3.15
urban	0.015	0.21
time	0.228***	2.86
intercept	18.547***	3.80
No of obs.		231
No of countries		23
Instruments		22
AR(1) test (p value)		-2.26 (0.024)
AR(2) test (p value)		0.71 (0.475)
Hansen test (p value)		13.60 (0.192)

Significance code: *** p<0.01, ** p<0.05, * p<0.1

Table 3: Two-Step GMM Estimates of T&D Losses Equation

The failure of independent regulators and private sector participation in SSA countries to reduce the energy losses can in part be explained by the need of the reforms to initially direct their efforts to improve the conditions of the generation segment of the sector. This, however, in practice, often tends to come at the expense of delays in the regulatory reform of the transmission and distribution network utilities where most of the energy losses occur. Indeed, economic regulation of network utilities has proven to be a rather difficult task in developed as well as in developing countries.

Do electricity reforms reduce the influence of corruption on technical efficiency? This can be examined through the two interaction terms *iraXcor* and *privXcor*. The coefficient of *iraXcor* is positive and significant suggesting that creations of IRAs have a statistical impact on the relation between corruption and technical efficiency. The estimated coefficient suggests that IRAs has partially mitigated the influence of corruption on technical efficiency. The establishment of IRAs acts as a limiting factor of losses when corruption increases, but also limits loss reduction as countries become less corrupt. Smith (2004) argues that reform policies such as the creation of IRAs were not effective in reducing energy losses and especially electricity theft in developing countries such as in SSA. The study attributed this to weak quality of governance such as, ineffective accountability and political stability.

The coefficient of the *privXcor* interaction term is positive but not significant suggesting that, the SSA countries that have opened their electricity sectors to private participation have not been able to offset the negative influence of corruption on efficiency. Similarly, the coefficient of the interaction term *iraXpriv* is negative but not significant indicating that regularised privatised networks have no effect on technical efficiency. It appears that even though IRAs on their own increase energy losses privatization has no effect on technical efficiency. Nagayama (2010) obtained a similar finding in the former Soviet Union, Eastern European and Latin American countries.

Regarding the control variables, the negative and significant coefficient of *hols* suggests that an increase in household demand for electricity has led to reduced T&D losses, likely due to a positive size effect. The coefficients of *struc* and *urban* are not significant and suggest that unbundling and urbanisation have not influenced technical efficiency during the period of our study. The coefficient of the time trend is positive and significant thus indicating that there has been an increase in the electricity losses of the countries over our sample period. It should be noted that this and the subsequent results should be interpreted with some caution since the dummies used are nominal values and thus may not capture the intensity of reform policies among countries in the sample. Moreover, the measure of corruption used is at best the perception of corruption, which could be different from reality.

Welfare Impact – Per Capita Electricity Consumption

The main aim of electricity sector reforms in developing countries has been to improve the socio-economic welfare of the population. The parameter estimates of the performance equation (*access*) are presented in Table 4. The estimated coefficient of *cor* is positive and significant, suggesting that, an increase in corruption (i.e., a decline in *cor*) decreases access to electricity services. This result is consistent with the findings by other studies on how corruption reduces the quality and quantity of publicly consumed services (e.g., Fredriksson et al., 2004; Estache et al., 2009).

The coefficient of the IRA dummy is positive and significant, indicating that for the period covered by our study, countries that have created IRAs have increased access to electricity. This result contrasts with those obtained by Estache et al. (2009) who associated the creation of IRAs with reduction in electricity access. The coefficient of *priv* is not significant indicating that the privatisation policies have no significant effect on electricity access. The estimate also contrasts with the findings of earlier studies such as Sihag et al. (2007) and Bhattacharyya (2006) who find that reform steps (e.g., privatisation) have led to a decline in access rates in the State of Orissa in India.

The coefficient of the interaction term *iraXcor* is positive and significant indicating that, creations of IRAs have amplified the influence of changes in corruption levels on electricity access, i.e., IRAs have been effective in enhancing electricity access when corruption has declined. The estimate of the interaction *privXcor*, is not significant suggesting that private sector participation has not been effective in addressing the negative influence of corruption. It may also suggest that corruption has not constrained the efforts of privatised utilities to increase access to electricity.

Regardless of the impacts of individual reform policies, the coefficient of *iraXpriv* suggests that together they exert a significant decreasing effect on access to electricity. In other words, although the creation of IRAs has led to increase in electricity access while privatisation has no effect, their interaction has led to reductions in electricity access. This may be attributed to the conflicting objectives of independent regulators and private utilities. Independent regulation may be keen to extend the often-subsidised service to mostly unelectrified poorer areas. However, private firms have shown little interest to extend the service to new low-income and low-usage consumer groups.

The coefficients of *gdpper*, *urban* and *struc* are all not significant suggesting that income level, the size, and the structure of electricity markets have no impact on electricity access.[12] The electricity generation per capita variable (*genper*) is positive and highly significant indicating that further increases in electricity generation leads to increase in electricity access. The time trend is not significant indicating that there has been no improvement in the electricity access of the region over time.

[12] The non-significant coefficient for *gdpper* could be related to an ambiguous relationship between per capita electricity consumption and income. It is expected that higher levels of per capita income imply higher per capita electricity consumption. However, it is also expected a negative relationship between these two variables for high levels of per capita GDP. This derives from the acquisition of more energy efficient appliances and the subsequent energy efficiency gains. We are grateful to an anonymous referee for pointing this out.

Welfare Impact (ln *access*)		
Variable	**Est.**	**t-stat.**
ln *access*(t-1)	0.871***	23.46
cor	0.093*	1.74
ira	0.270***	2.86
priv	-0.051	-1.00
struc	0.032	1.09
iraXcor	0.157**	2.06
privXcor	-0.106	-1.60
iraXpriv	-0.209***	-2.97
ln *genper*	0.092**	2.17
ln *gdpper*	0.018	0.41
urban	0.001	0.92
time	0.001	1.13
intercept	-0.167	-0.62
No of obs.		515
No of countries		47
Instruments		37
AR(1) test (p value)		-4.04 (0.000)
AR(2) test (p value)		-1.55 (0.120)
Hansen test (p value)		31.74 (0.134)

Significance code: *** p<0.01, ** p<0.05, * p<0.1

Table 4: Two-Step GMM Estimates of Per Capita Energy Consumption Equation

Economic Impact – GDP Per Capita

The earlier results indicated that the implementation of electricity reforms in SSA countries can reduce the negative influence of corruption on the performance of the sector. Similarly, the implementation of reforms in developing countries was noted to have anticorruption potentials to reduce the effects of corruption on economic development (World Bank, 2000). Therefore, we expect the electricity reforms in SSA to enhance economic performance at two levels. First, by enhancing the performance of the sector by improving technical efficiency and extending the service to those without access. Second, as part of wider economic reforms, often underpinned by an anticorruption strategy, the reforms can reduce the effect of corruption on economic performance.

In Table 5, where *gdpper* is a dependent variable in the performance equation, the coefficient of *cor* is positive and significant indicating that a decrease in corruption augments national income. This is consistent with other well-established findings on the relationship between these two variables (e.g., Barreto, 2000; Rose-Ackerman 1999; Shleifer and Vishny 1993). Thus, an increase in the corruption control index is associated with an increase in per capita GDP. The coefficient of *ira* is not significant; suggesting that creation of IRAs has not had impact on the level of income.

Economic Impact (ln *gdpper*)		
Variable	**Est.**	**t-stat.**
ln *gdpper*(t-1)	0.565***	7.20
cor	0.261***	3.38
ira	-0.050	-0.51
priv	0.140**	2.34
struc	0.237***	4.32
iraXcor	-0.185	-1.63
privXcor	0.238**	2.34
iraXpriv	0.006	0.10
urban	0.014***	3.75
time	0.001	0.73
intercept	2.563***	5.98
No of obs.		515
No of countries		47
Instruments		41
AR(1) test (p value)		-2.57 (0.010)
AR(2) test (p value)		-1.13 (0.259)
Hansen test (p value)		30.45 (0.443)

Significance code: *** p<0.01, ** p<0.05, * p<0.1

Table 5: Two-step GMM Estimates of Per Capita Income Equation

The coefficient of *priv* is positive and significant indicating that private sector investments have boosted economic performance of SSA reforming countries. A similar result was obtained by Chisari et al. (1999) who find privatisation of electricity generation and distribution assets led to positive economic performance in Argentina. Similarly, the estimate of *priv* confirms the argument by the IMF that ESR policies such as privatisation has the potential to free up energy subsidies and thereby boost economic performance over the long run (IMF, 2013).

Do the electricity reforms reduce the negative association between corruption and economic growth? The coefficient of *iraXcor* is not significant suggesting, that, for the period of this study, countries that established IRAs have not exerted beneficial effects on the negative association between corruption and per capita GDP nor has corruption affected the relation between regulation and economic performance. This is inconsistent with Jalilian et al. (2007) who stressed the importance of credible and independent regulation on economic growth. The coefficient of *privXcor* is positive and significant indicating that countries that open their electricity sectors to private investments have seen reinforced the influence of corruption on per capita GDP. Thus, countries with lower corruption levels have had further success in boosting income levels through private participation in the electricity sector.

The coefficient of *iraXpriv* is not significant suggesting that the interaction of the regulator and privatisation does not exert an influence on the economic performance. One of the two control variables in the model, *struc*, is positive and significant. This suggests that unbundling impacted positively on per capita GDP, after controlling for the effect of corruption. The time trend variable is significant which indicates that per capita GDP has increased over the period covered by our study.

6. Conclusion and Policy Implications

Sub-Saharan African countries are noted to have some of the highest levels of corruption in the world. Various studies have studied how corruption has constrained the economic development of these countries through different transmission channels. However, one important transmission channel not yet investigated is the organisation and regulation of the electricity sectors. Research that has analysed this channel in other developing regions has found that corruption can reduce technical efficiency, restrict access to electricity services to urban areas, and reduce income levels.

In order to mitigate the influence of corruption in the electricity sector, reformers have called for the unbundling of state-owned utilities vertically (generation, transmission, distribution, and retailing) and horizontally (generation and retailing). The unbundled parts that are amenable to competition could be sold to the private sector and an independent regulatory agency would supervise and regulate the natural monopoly-prone networks of the sector.

After more than two decades of electricity reforms in SSA, we can now study whether the reforms have reduced the influence of corruption on technical efficiency of the sector and whether the efficiency gains have resulted in higher electricity access and incomes. We use a purpose-built panel dataset and a dynamic panel estimator to investigate the effects of corruption on the performance of the sector. Using World Bank's control of corruption perception index, we show that corruption has an adverse and statistically significant effect on three performance indicators – i.e. technical efficiency, access to electricity and economic performance. This finding adds to the body of evidence that stress the detrimental impacts of corruption on economic development and electricity sector performance.

We find that the creation of independent regulators and private sector participation, not only can enhance the performance of the sector but they can also have wider economic benefits. Specifically, we find that independent regulation can increase social welfare although it can also reduce technical efficiency. In addition, we show that private sector participation is associated with improved economic performance, while we find that privatisation policies have no statistically significant impact on electricity access and technical efficiency.

We also analyse how corruption interacts with different reform steps and how these interactions impact on the three indicators of performance. The creation of independent regulators has mitigated the association between corruption and technical efficiency, while it has amplified the relationship between corruption and electricity access, i.e., independent regulation has been effective to enhance electricity access in less corrupt countries. We also find that creations of independent regulators have not mitigated the often-cited negative association between corruption and income level. Private sector participation has reinforced the influence of corruption on income. Thus, countries with lower corruption levels have had further success in boosting income levels through private participation in the electricity sector. However, private participation has no impact on the association between corruption and electricity access and technical efficiency.

Our results suggest that implementation of well-designed micro level electricity reforms have the potential not only to boost the firms' economic performance directly, they would also indirectly reduce the negative effects of macro-level institutional deficiencies such as corruption on micro and macro levels indicators of performance. For example, one of the policy implications from our results is the benefit of having an independent regulator that is transparent, fair, and accountable with the capacity for producing credible and predictable policies and with commitments to cost-reflective tariffs and protection of consumer interest.

Establishing such an institutional body would not only help reduce uncertainties surrounding issues related to market access, tariffs, and revenues but also help improve the overall governance of the sector.

By improving sectoral governance, the regulator would reduce the need for risk mitigation measures such as World Bank guarantees, ring-fencing of revenues accruing to off-takers[13] and other measures required by investors when investing in SSA countries' power markets. Thus, by serving as a risk mitigator, the regulator would help attract the crucial investments needed to upgrade and build new transmission and distribution infrastructures and increase generation capacities thereby improving the overall performance of the sector.

Another finding of our study highlights the importance of privatizing SSA countries' state-owned utilities and incentivising private investors through well-delineated electricity policies that would be easily translated into investment opportunities. Therefore, at crux of the electricity reform should the desire to encourage investments needed to increase efficiency by reducing the large T&D losses which are the main feature of sectors in SSA electricity sectors. Also, privatised utilities when incentivised, would reduce nontechnical or commercial losses by improving metering, billing, and collection of tariffs, monitoring consumption regularly, particularly of the high-value consumers, and by enforcement of payment discipline among consumers.

Furthermore, the financial viability of the off-takers is important for attracting private investments since full wholesale or retail competition has not been achieved in the power sectors of the region.[14] This is because a financially fragile off-taker that does not recover

[13] This would boost the creditworthiness of the off-taker.
[14] Despite reforms the SSA countries' state-owned utilities have remained the major buyers power.

enough revenue from consumers, would threaten the viability of whole system since it would be difficult for power generators to pay primary energy suppliers.

Although, our results emphasise the importance of independent regulation and private sector participation, this does not suggest that other aspects of the reform model such as unbundling and competition are irrelevant or unimportant. For example, unbundling would have the effect of levelling the playing field for private generating plants, while competition would allocate resources efficiently and lower tariffs for consumers. Therefore, all aspects of the reform model are important for improving the sectoral governance, strengthening the enabling environment, and reduce the risk perceived by prospective investors.

Overall, this paper shows that implementation of electricity reforms in SSA countries have, to some extent, addressed the root cause of inefficiency and low access and thus have moved utilities towards better performance through cost recovery in pricing and improved metering, billing, and revenue collection. By improving the performance of the sector, some aspects of reforms have boosted economic performance, since improvements in technical efficiency can be translated into higher electricity access and national income.

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Appendix A

Country	Year of financial closure	Name of Project	Subtype of PPI	Project status	Segment
Chad	2000	Societe Tchadienne d'Eau et d'Electricite (STEE)	Management contract	Cancelled	G*, T** & D***
Gabon	1993	Societe Africaine de Gestion et d'Investissement (SAGI)	Management contract	Concluded	G, T & D
Gambia	1993	Management Service Gambia (MSG)	Lease contract	Cancelled	G, T & D
Gambia	2006	National Water and Electricity Company Management Contract	Management contract	Concluded	G
Ghana	1994	Electricity Corporation of Ghana	Management contract	Concluded	D
Guinea-Bissau	1991	Electricidade e Aguas de Guinea-Bissau	Management contract	Concluded	G, T & D
Kenya	2006	Kenya Power and Lighting Company Management Contract	Management contract	Concluded	T & D
Lesotho	2002	Lesotho Electricity Corporation (LEC)	Management contract	Active	G, T & D
Liberia	2010	Liberia Electricity Corporation Management Contract	Management contract	Active	T & D
Madagascar	2005	Jiro syRano Malagasy (Jirama)	Management contract	Concluded	G, T & D
Malawi	2001	Electricity Supply Corporation of Malawi Ltd (ESCOM)	Management contract	Concluded	G, T & D
Mali	1994	Electricite et Eau du Mali (Management)	Management contract	Concluded	G, T & D
Namibia	1996	Northern Electricity	Lease contract	Concluded	D
Namibia	2000	Reho-Electricity	Lease contract	Active	D
Rwanda	2003	Electrogaz	Management contract	Cancelled	G, T & D
Rwanda	2003	Electrogaz	Management contract	Cancelled	G, T & D
São Tomé and Principe	1993	Empresa de Agua e Electricidade	Management contract	Concluded	G, T & D
Tanzania	2002	Tanzania Electricity Supply Company (TANESCO)	Management contract	Concluded	G, T & D
Togo	1997	Companie Energie Electrique du Togo	Management contract	Concluded	G & D
*Generation, **Transmission and ***Distribution					

Table A1. Types of Management Contracts in SSA
Source: World Bank PPI database

Appendix B: Electricity Consumption Per Capita as a Proxy for Access

In order to assess the impacts of corruption and ESR on electricity access, we use per capita electricity consumption as dependent variable in Equation (1). Although this choice of dependent variable may have some limitations, there are several reasons why it is a better proxy than other two alternative measures commonly used by other scholars: IEA data on electricity access rates and night-time satellite imagery data captured by the US Defence Meteorological Satellite Program's Operational Linescan System (DMSP-OLS).[i]

The IEA data, which was first compiled in the "World Energy Outlook, 2002", was based on various sources such as countries' self-assessed reports (World Bank and IEA, 2015), which magnifies the sources of errors and thus leads to overestimation of access rates (Min, 2010). Another drawback of the IEA data is that, it only indicates the extent of electricity infrastructure provision, and therefore is silent on quality, reliability and whether services has been consumed or not (World Bank and IEA, 2015; Ahlborg et al., 2015).[ii]

Similarly, night-time satellite imagery has some serious drawbacks. For example, the measure includes people without access to electricity services residing in electrified towns (Doll and Pachauri, 2010). As a result, its reliability as an indicator of access rate is weak since it only measures stable outdoor lights, which can be a major problem in SSA countries where there are high incidences of load shedding (World Bank, 2009).[iii]

Therefore, using consumption per capita other than connection rates or satellite imagery as dependent variable has the advantage of assessing how consumers were able to translate access

[i] The data is archived and provided to researchers by the National Oceanic and Atmospheric Administration (NOAA) at its National Geophysical Data Centre.
[ii] For further discussion, see Ahlborg et al. (2015).
[iii] For further shortcomings of this data, see Doll and Pachauri (2010).

to real use, rather than just the physical extension of electricity infrastructures. As result, if there are significant changes in service reliability, we expect that consumption to be adversely affected. Moreover, as Ahlborg et al. (2015) note, using a per capita measure rather than measuring average consumption among the electrified minority has the advantage of comparing development patterns across SSA countries of different population sizes. Furthermore, the per capita measure allows for the assessment of whether consumption levels have kept pace with population growth in each country. Thus, the proxy is a good indicator of whether ESR policies have improved quality, increase access to hitherto derived areas, and/or whether the population of those already connected have increased over time.

Appendix C: Robustness Analyses

It is possible that the coefficient estimates in Tables 3, 4 and 5 may suffer from omitted-variable bias. Here we check the robustness of our results by adding additional explanatory variables in the model, one at a time to the three estimated equations to examine whether this would significantly affect the results.

Cubbin and Stern (2006) argue that a rapid growing share of industrial output (e.g., in heavy industry such as petrochemicals, aluminium, manufacturing) is expected to increase the demand for electricity. Similarly, Kaldor (1970) and Cornwall (1977) argue that expansion of the industrial sector is a driving force for economic development. Thus, excluding this variable (*ind*) from the estimated equations could, potentially, lead to biased estimates of the effects of ESR and corruption on the three indicators of performance. We therefore include the share of industrial value added as a percentage of GDP as an additional regressor in three equations. Several authors also find the degree of openness of an economy to influence electricity sector performance (e.g., Zhang et al., 2008). We also include exports (*export*) as percentage of GDP as an additional regressor in the performance equation. The data for *export* is obtained from the World Bank governance indicators database.

Furthermore, several studies include a variable measuring population density to assess the ability of both public and private utilities to extend low cost and affordable electricity to populations spread over vast areas (e.g., Ahlborg et al., 2015; Estache et al., 2009; Min, 2010). The data is from the World Bank development indicators database.

Results of this exercise are presented in Tables C1, C2 and C3. Columns 1, 3 and 5 of each table presents the parameter estimates of the models when *ind*, *export* and *popden* are added, one at time, as an additional regressors to the three performance regressions. The coefficients of *cor*, *ira*, *priv* remained significant/not significant depending on the performance indicator with the expected signs regardless of the additional regressors added to the three equations. The only exception is *priv* in two of the energy losses equations, which shows a significant and positive coefficient while this was found not significant in Table 3. Similarly, the coefficients of the two interactions of interest, *iraXcor* and *privXcor*, remain significant/not significant in most cases (except the coefficient *iraXcor* in the per capita GDP equations and *privXcor* in one of the energy losses equations and one of the per capita GDP equations) regardless of extra additions to the three regressions.

Therefore, we consider that the additional inclusions do not significantly alter the estimates of the coefficients for *cor*, *ira* and *priv*. Moreover, the estimates relative to the two interaction terms (*iraXcor* and *privXcor*) remain relatively stable regardless of which of the additional variables is introduced in the performance equations. These results seem to indicate that the estimates presented in Tables 3, 4 and 5 are not suffering from omitted-variable bias.

Technical Impact (*losses*)						
	ind		*ind* + *export*		*ind* + *export* + *popden*	
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Variable	**Est.**	**t-stat.**	**Est.**	**t-stat.**	**Est.**	**t-stat.**
losses(t-1)	0.646***	3.93	0.477**	2.11	0.421***	2.82
cor	-30.031***	-4.38	-37.408**	-2.00	-35.648**	-1.97
ira	20.383***	3.07	50.552**	2.34	39.746**	2.57
priv	11.361	1.17	41.181*	1.70	49.538**	2.29
iraXcor	15.939*	1.94	28.549**	2.23	24.909***	2.69
privXcor	14.790	1.43	8.439	0.55	32.972**	2.32
iraXpriv	4.042	0.44	-26.730**	-1.98	-29.135**	-2.27
ln *hols*	-5.170***	-2.62	-2.241	-0.80	-6.426**	-2.05
struc	1.052	0.34	-2.082	-0.57	1.913	0.57
urban	0.304	1.11	0.587*	1.86	-0.030	-0.12
ind	-0.438	-1.02	0.236	0.90	0.498	1.54
export			-0.273**	-2.04	-0.582*	-1.73
ln *popden*					8.424***	3.26
time	-0.233	-0.94	-0.209	-0.58	0.603**	2.02
intercept	15.236	1.16	-50.491	-1.51	-18.420	-1.53
No of obs.		217		206		206
No of countries		22		22		22
Instruments		20		20		22
AR(1) test (p value)		-2.33 (0.020)		-1.68 (0.093)		-1.99 (0.046)
AR(2) test (p value)		0.73 (0.465)		0.21 (0.831)		-0.61 (0.544)
Hansen test (p value)		6.46 (0.487)		7.61 (0.268)		2.77 (0.906)

Significance code: *** p<0.01, ** p<0.05, * p<0.1

Table C1: Two-Step GMM Estimates of T&D Losses Equation

Welfare Impact (ln *access*)						
	ind		***ind* + *export***		***ind* + *export* + *popden***	
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Variable	**Est.**	**t-stat.**	**Est.**	**t-stat.**	**Est.**	**t-stat.**
ln *access*(t-1)	0.916***	151.42	0.920***	121.58	0.915***	87.88
cor	0.093***	3.19	0.049**	2.22	0.068*	1.80
ira	0.084**	2.42	0.130***	5.60	0.127***	3.81
priv	-0.003	-0.08	0.036	1.47	-0.012	-0.35
iraXcor	0.044*	1.93	0.020*	1.89	0.077***	3.90
privXcor	-0.009	-0.23	0.038	1.25	-0.020	-0.49
iraXpriv	-0.081*	-1.72	-0.116***	-5.24	-0.091***	-3.01
ln *genper*	0.046***	5.59	0.031***	3.47	0.048***	4.43
ln *gdpper*	0.005	0.49	0.011*	1.69	-0.006	-0.38
struc	0.048***	3.70	0.047***	6.05	0.046***	4.72
urban	0.001***	3.65	0.001**	2.10	0.001	-0.55
ind	0.002***	3.90	0.001	1.29	0.002***	2.70
export			0.002***	5.61	0.001***	2.73
ln *popden*					-0.003	-0.70
time	0.002***	2.85	0.001*	1.71	0.003***	2.61
intercept	-0.141***	-2.59	-0.246***	-4.88	-0.069	-0.75
No of obs.		480		454		452
No of countries		45		44		44
Instruments		43		44		44
AR(1) test (p value)		-4.13 (0.000)		-4.10 (0.000)		-4.12 (0.000)
AR(2) test (p value)		-1.53 (0.125)		-1.59 (0.111)		-1.35 (0.178)
Hansen test (p value)		26.55 (0.596)		28.10 (0.512)		22.12 (0.776)

Significance code: *** $p<0.01$, ** $p<0.05$, * $p<0.1$

Table C2: Two-Step GMM Estimates of Per Capita Energy Consumption Equation

Economic impact (ln *gdpper*)						
	ind		***ind + export***		***ind + export + popden***	
	(1)	**(2)**	**(3)**	**(4)**	**(5)**	**(6)**
Variable	**Est.**	**t-stat.**	**Est.**	**t-stat.**	**Est.**	**t-stat.**
ln *gdpper*(t-1)	0.466***	8.73	0.716***	14.41	0.824***	25.51
cor	0.199**	2.44	0.185***	3.51	0.085*	1.78
ira	0.050	0.55	-0.056	-1.21	-0.014	-0.22
priv	0.272***	3.38	0.080*	1.79	0.214***	3.69
iraXcor	-0.248***	-3.37	-0.116***	-6.66	-0.264***	-4.90
privXcor	0.239**	2.04	-0.016	-0.32	0.266***	4.27
iraXpriv	-0.116*	-1.72	-0.062	-1.27	-0.121**	-2.58
struc	0.163***	3.51	0.103***	5.37	0.098***	3.25
urban	0.016***	5.91	0.007***	3.29	0.005***	3.88
ind	0.007***	5.93	0.002***	4.38	0.002**	2.46
export			0.004***	4.83	0.002***	2.98
ln *popden*					-0.005	-0.39
time	0.001	-0.08	0.001	0.41	-0.001	-1.43
intercept	2.810***	10.76	1.587***	6.19	0.947***	4.96
No of obs.		480		454		452
No of countries		45		44		44
Instruments		42		43		39
AR(1) test (p value)		-2.29 (0.022)		-3.17 (0.002)		-3.01 (0.003)
AR(2) test (p value)		-0.66 (0.510)		-1.21 (0.226)		-1.13 (0.257)
Hansen test (p value)		26.38 (0.655)		20.35 (0.907)		21.06 (0.689)

Significance code: *** p<0.01, ** p<0.05, * p<0.1

Table C3. Two-Step GMM Estimates of Per Capita Income Equation